PCAS 18 (2015/2016)

Supervised Project Report
(ANTA604)

Antarctica School Units for Levels 3, 4 &5

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Word count: 8,036

Abstract (ca. 200 words):

There are three topics developed for primary age pupils, Antarctica and Gondwanaland, The Antarctic Food Web and Living in the Extreme Environment of Antarctica. Each unit has four sections; an introductory section of information, some suggestions for questions and discussion, pen and paper activities and practical work. Several websites are suggested as resources for teachers.
Each topic has two units, one aimed at Level 3 & 4 and the other for Level 5.
The Achievement Aims for each unit are listed in the contents page at the beginning of this report. The Nature of Science is also considered as the units develop scientific thinking with the activities, research and experiments suggested.
These units could be taught as stand-alone units or within a study of Antarctica over a longer period.

These resources are Educational resources for teachers to deliver Antarctic–focused lessons. A further step is to share these lessons with other teachers and to run a workshop for teachers wanting to teach about Antarctica. This would be a collaboration with Antarctica NZ and involve promoting Learnz, the interactive field trip site.

Antarctic Units

Contents

Gondwanaland and the Geological history of Antarctica

Level 3 & 4, Level 5

Making sense of Planet Earth and Beyond

Achievement Objective

- Investigate the geological history of planet Earth and understand that our planet has a long past and has undergone many changes.
- Appreciate that science is a way of explaining the world and that science knowledge changes over time.

The Antarctic Food Web

Level 3 & 4, Level 5

Making sense of the Living World

Achievement Objectives

- Gain an understanding of the order and pattern in the diversity of living organisms
- Investigate and understand relationships between structure and function in living organisms
- Investigate ecosystems and understand the interdependence of living organisms and their relationship with their physical environment
- Begin to use a range of scientific symbols, conventions and vocabulary

Exploring the Extreme environment of Antarctica

Level 3 & 4

Achievement Aims

Making sense of the Living World

- Relate the observed, characteristic chemical and physical properties of a range of different materials to technological uses and natural processes.

Life in the extreme environment of Antarctica

Level 5

Achievement Aims

Living World

- Identify the key structural features and functions involved in the life processes of plants and animals.
- Investigate and understand the relationships between form and function in living organisms.

Gondwanaland and the Geological History of Antarctica Level 3 & 4

Main teaching ideas;

1. **The development over time of scientific theories to explain continental drift**
2. **There is evidence supporting the theory of Gondwanaland**
3. **Understanding the mechanisms that drive plate tectonics**
4. **Identification of the different boundaries formed by plate tectonics**
5. **Antarctica's geological history as part of Pangaea and Gondwanaland.**

Key words; Pangaea, Gondwanaland, continent, fossil, plate tectonics, paleontologist.

Antarctica and Gondwanaland

Science History

Scientists had noticed that the coast lines of Africa and South America could fit together.

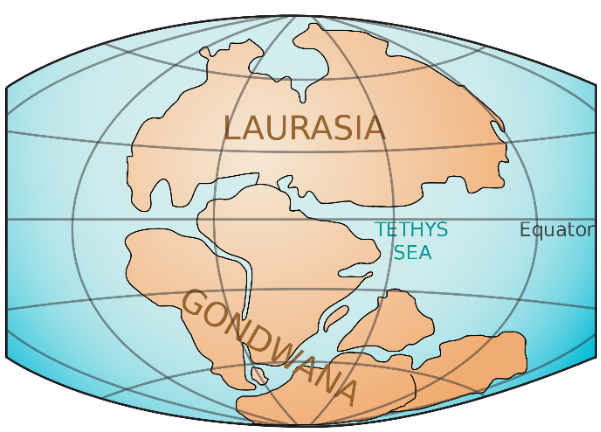
In the 1920's **Alfred Wegener** proposed the theory of **continental drift**; that there was one super continent, **Pangaea,** (meaning all lands), and that this broke up, forming the continents of today. Originally his ideas were thought to be incorrect as no one could explain how the continents could have moved over time. By the 1960s with increasing scientific evidence and the development of the modern science of **plate tectonics**, the movements of the Earth's crust driven by the convection currents in the mantle of the Earth, meant that Wegener's theory was accepted. We now know that the jigsaw of massive plates on the Earth's surface are still moving slowly, at a speed of around 5cm a year.

Super Continents

The super continent of **Pangaea** broke into two main groups of continents that drifted in different directions.

Laurasia which drifted north and separated into Europe, Asia and North America

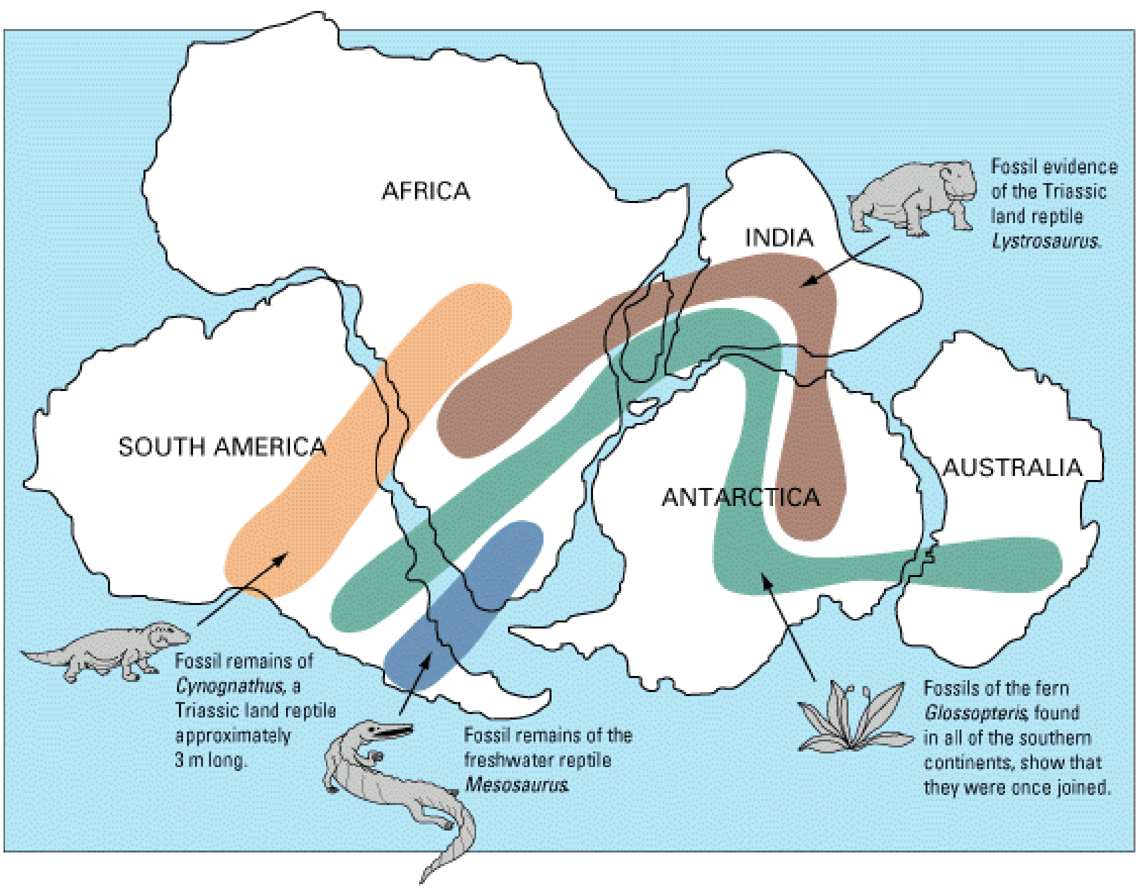
Gondwanaland which split into Antarctica, New Zealand, Australia, South America, Africa and India.



TRIASSIC
200 million years ago

Gondwana

1. The name *Gondwana* comes from the *Gonds*, an ancient tribe living in India and *Wana,* which means land.
2. Until about 140 million years ago, East Antarctica was the centre of the ancient southern land mass of Gondwana.
3. After that time, Gondwana split up into the continents of Antarctica, South America, Africa and India. New Zealand started to break away from Antarctica about 80 million years ago and Australia about 55 million years ago.
4. Ancient rocks have been found in Antarctica which are similar to ones in parts of India and Australia.
5. Rocks dumped by ice sheets have been found in Antarctica, Australia, India and South Africa.
6. Fossil remains of the tree *Glossopteris* have been found over much of "Gondwana", including Southland (New Zealand).
7. Fossil remains of the fern *Dicroidium* have been found in Antarctica, South Africa, South America and Australia.
8. Fossil remains of the land-based fern-browsing reptile *Lystrosaurus* have been found in Antarctica, Africa and India. As this reptile couldn't swim across oceans, the continents must have moved to their present position.



Fossil Evidence

When animals or plants are rapidly buried in layers of mud during a natural catastrophe, their bodies are protected from normal processes of decay: scavengers, bacteria, and chemicals are prevented from breaking down their bodies at the usual rate. The hard parts of the animals (such as their bones, teeth, and shells) are eventually replaced with minerals from the mud, which turn them into rock. The soft parts of the specimen, such as the scales of a fish or the leaves of a plant, sometimes leave a coloured imprint in rock before they eventually decay. Trees or other organic matter that are covered with silica-rich water become petrified--they turn into solid mineral. All of these methods result in what we know as fossils. A ***palaeontologis****t* is a scientist who studies fossils to find out more about extinct species or about any species that are evident in the fossil record.

The fossils that link the continents have been important evidence to prove the existence of the super continents of Pangaea and Gondwanaland. **Captain Robert Falcon Scott** and his expedition party found, and carried back from their ill-fated journey to the South Pole in 1912, fossils of the **Glossopteris indica**, an ancient beech like tree. This 250 million year old fossil has been found in all the other continents that made up Gondwanaland. Antarctica must have been warmer and ice free for this tree to grow.

Glossopteris indica an extinct beech-like tree fossil

Questions/think pair share/discuss

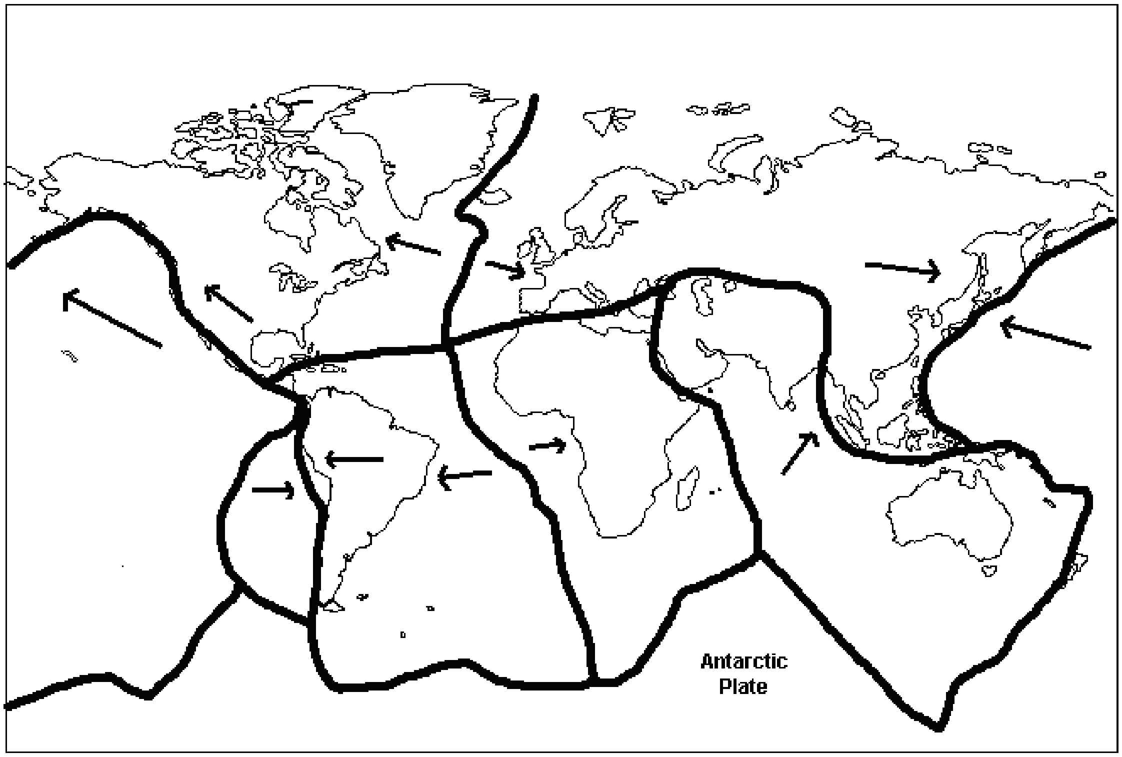
1. What is the evidence for Gondwanaland?
2. Why do you think people took a long time to understand that the continents were once joined together?
3. The India has a research station in Antarctica close to where India was once thought to have been attached to Antarctica. What do you think scientists might be looking for?

Activities

1. Make a time line from Gondwanaland to the placement of the present day continents.
2. Make a flow chart diagram that shows the division of the super continent Pangaea into Laurasia and Gondwanaland, and then into the continents of today.
3. Listen to the Alfred Wegener song https://www.youtube.com/watch?v=T1cES1Ekto
4. Watch the information clip on Alfred Wegener's theory of Continental Drift. Take notes and ideas down. Share main ideas from the clip in the link http://www.britannica.com/science/continental-drift-geology
5. Go to the interactive site below and try the activites there https://www.learner.org/interactives/dynamicearth/drift3.html

6. Use the tectonic plate jigsaw map to see how the plates fit together. Cut and move them around. Notice the way the arrows are moving. What do you think

will be happening at the plate boundaries?



Practical work

Plate movement

1. Add cold honey, corn syrup or golden syrup to a beaker. Place two halves of a biscuit on top of the honey or golden syrup. Gradually heat. What happens to the biscuit?
2. In a saucepan pour a litre of cream or milk. Add a layer of cocoa powder to cover the milk (2cm). Gradually heat until milk bubbles through. Identify the movement of the cocoa as continental drift.

Making a fossil

Fossils are most commonly found in limestone, shale, and sandstone, all relatively soft rock that erodes more easily than most rocks do. As the rock gradually wears away, the fossil layers within it are exposed. To demonstrate how fossils are made you can make fossil 'casts' or prints out of plaster.

1. Fill a clean tuna can or shallow bowl to a depth of about 3am with modelling clay.

2. Press a plastic animal, rock or other object halfway into the clay

3. Remove the object, leaving a clear imprint in the clay.

4. Mix plaster of paris with water until the consistency is similar to pancake batter. Pour the plater into the can over the clay, filling the imprint.

5. Let the plaster dry for 24 hours.

6. Separate any remaining clay from the plaster to reveal a 'fossil' of the object

The Geological History of Antarctica Level 5

Main teaching ideas;

6. **There is evidence supporting the theory of Gondwanaland**
7. **Understanding the mechanisms that drive plate tectonics**
8. **Identification of the different boundaries formed by plate tectonics**
9. **Antarctica's geological history as part of Pangaea and Gondwanaland.**

Key words; Pangaea, Gondwanaland, continent, fossil, tectonic plates, magma, 4 types of plate boundaries; divergent, convergent, subduction, transform (slide)

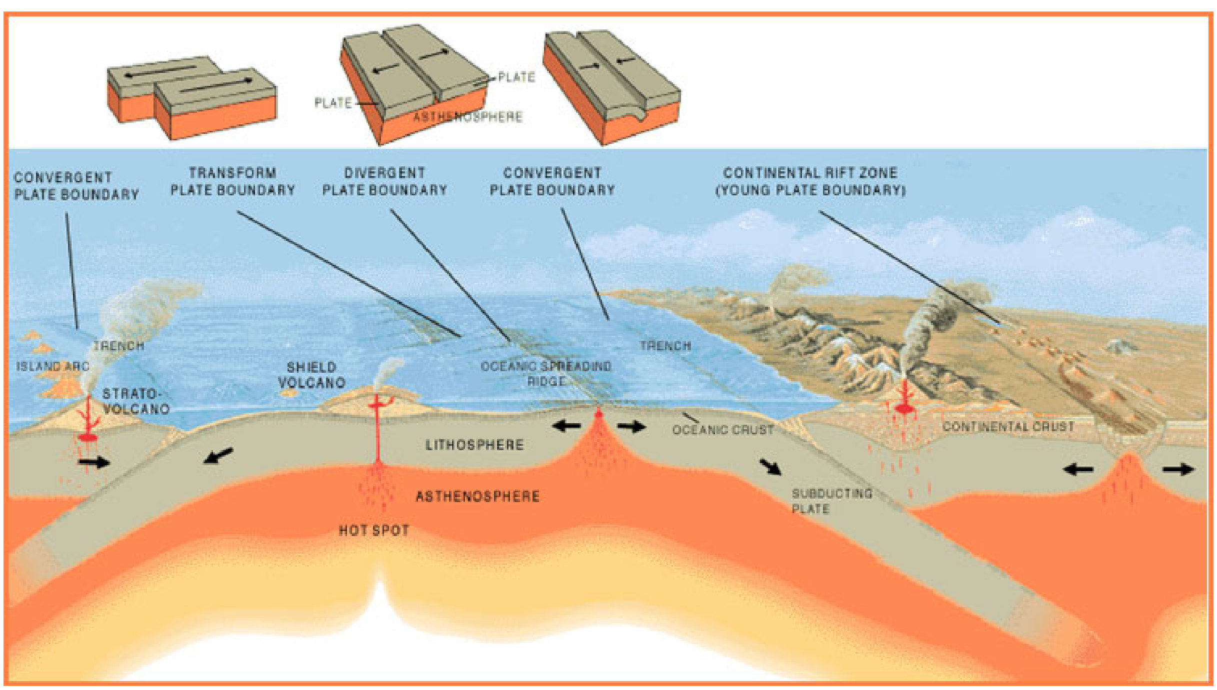
From Continental Drift to Plate Tectonics

In the 1920's a scientist, Alfred Wegener, concluded from the jigsaw appearance of the Earth's coast lines that the continents had once been joined together and had moved slowly apart over time. Wegener's theory of **Continental Drift** was initially not accepted as his fellow scientists thought there was not enough evidence for his ideas. Fossil evidence and an understanding of how the continents moved led to an acceptance of his ideas in the 1960's. His theory led to the modern science of **plate tectonics**. Convection currents in the mantle of the Earth cause heated rocks to rise and fall again as they cool. These convection currents are moving the continents of the Earth at a rate of about 5cm a year. Where the plates meet are called **plate boundaries**. Volcanoes, earthquakes, mountain ranges and ocean trenches found along the edge of these boundaries.

The different boundaries are;

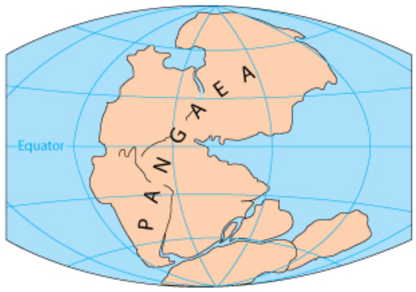
1. **Convergent**, where the plates move together.
2. **Subduction**, when converging plates are moving together and one plate slides under the other.
3. **Divergent**, where the plates move apart.
4. **Transform**, where the two plates slide past each other.

http://oceanexplorer.noaa.gov



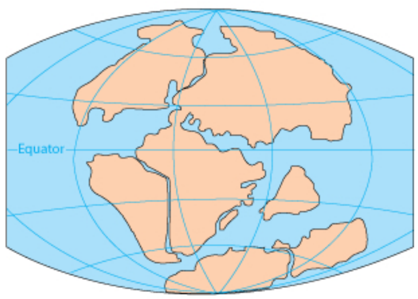
From Pangaea to Gondwanaland to Antarctica

250 million years ago Antarctica was part of a super continent that we now call **Pangaea**.
The super continent called Pangaea moved apart and split into two large land masses; **Laurasia** and **Gondwanaland**.
Laurasia drifted north and divided into Europe, Asia and North America. Gondwanaland became Antarctica, Africa, South America, India, Australia and New Zealand.
Although most of these latter land masses stayed in the southern hemisphere, one of them did not. India moved north, eventually colliding with the east Asian land mass and forming the Himalayas.

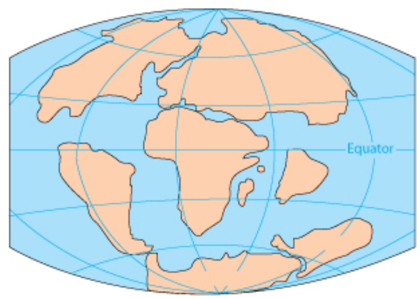


PERMIAN
250 million years ago

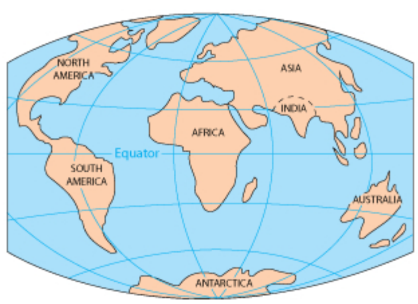
TRIASSIC
200 million years ago



JURASSIC
145 million years ago



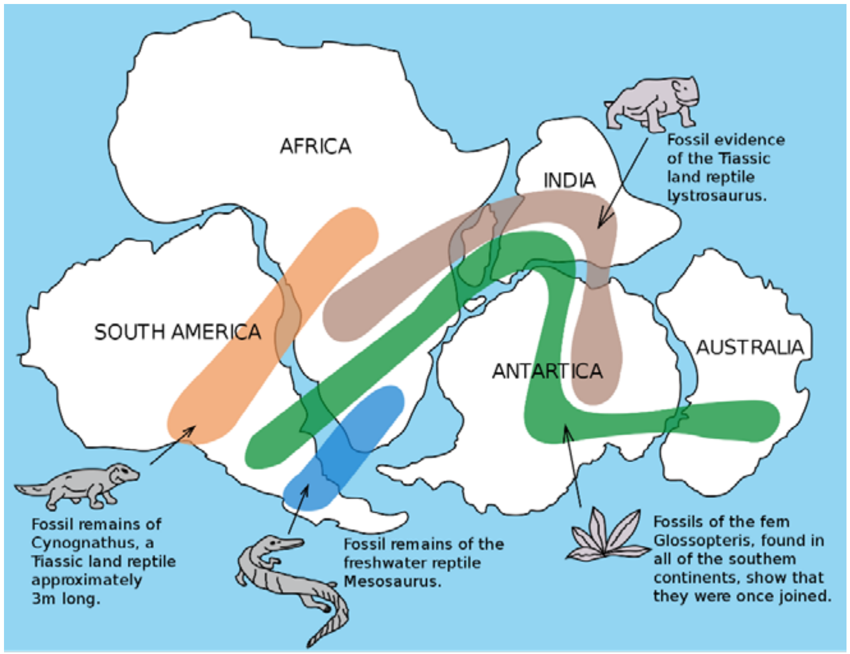
CRETACEOUS
65 million years ago



PRESENT DAY

Fossil Evidence

Fossil evidence links all the land masses that once formed Gondwanaland together. Captain Robert Falcon Scott found fossils of the *Glossopteris indica*, an extinct type of beech tree on his way to the South Pole. Although he would not have known the full importance of the fossils when they discovered them in Antarctica, the heavy rock fossils were found with Scott and his party in their tent. Scott and four of his expedition team were beaten to the South Pole by Roald Amundsen in 1912 and tragically perished on their return journey. The discovery of the tree fossil indicates that the climate would have been warmer in Antarctica at the time this plant grew there, 250 million years ago.



Questions / think pair share / discuss

1. What do you think the edges of the different plate boundaries will look like?
2. Where is the Rift Valley ? Why do you think it is called that ?
3. Discuss the fossil evidence for Gondwanaland. Is it convincing?
4. What do you think this fossil evidence can tell us about the climate at the time of Gondwanaland ?

Activities

1. Watch the clip; http://www.pbslearningmedia.org/resource/ess05.sci.ess.earthsys.plateintro/plate-tectonics-an-introduction/

2. Check out this link for further information about Plate Tectonics

   www.geography.learnontheinternet.co.uk/topics/structureofearth.html#struct

3. From the link above make up and complete a table summarizing the four different types of plate boundaries.

Plate boundary	Diagram	Description	Landform	Example

4. Complete the cloze exercise below.

Pangaea was a super continent that split into ____________________ and _________________ about 250 million years ago. The northern super continent of Laurasia later split into Europe, Asia and North America while the southern super continent of Gondwanaland would eventually split into Africa, India, Madagascar, South America, Australia and Antarctica. This process was driven by _____________pushing upwards and creating pressure on the Earth's crust. Australia and Antarctica stayed together until about ____________________years ago, when Antarctica started to freeze and Australia drifted northward. The Australian continent is still moving north at a rate of 3cm a year. While ___________________was part of Gondwanaland the planet was warmer than it is today. There was no Antarctic ice-sheet and _________________ roamed the Earth. This was the _______________period and much of Gondwanaland was covered with lush _______________. _________________found by scientists over the years have provided evidence that these land masses were once joined together. From a Viennese geologist, Eduard Suess in the mid-1800s to Captain Robert Scott in 1912, to scientists later in the 20th century, all who collected fossils without understanding the process of______________________________, there was a growing awareness of the significance of these fossils. The name Gondwanaland comes from an area in ____________________ where geological formations match those found in the _____________________ hemisphere.

45 million	**magma**	**Jurassic**	**Fossils**
southern	**plate tectonics**	**Gondwanaland**	**India**
Antarctica	**rainforest**	**dinosaurs**	**Laurasia**

Practical Work

1. Using a Mars bar, one per student if possible, explore how a Mars bar can demonstrate plate boundaries.
   - Carefully break the hard chocolate surface (the Earth's crust) by bending the bar.
   - When the caramel layer (the mantle) is exposed, pull gently to show divergent plates.
   - Continue, demonstrating convergent, subducting and transforming tectonic plates.
   - You may now eat the experiment

2. Pour a thick liquid; honey, golden syrup or corn syrup into a large beaker.
   Place pieces of a broken biscuit on top of the liquid and gently heat, demonstrating the movement of the continents.

The Antarctic Food Web Level 3 & 4

Making sense of the Living World

Main ideas;

1. **Definition of a food chain.**
2. **The arrow in a food chain or food web points in the direction of the energy flow or means "is eaten by"**
3. **Producers start a food chain as they are able to make their own food using sunlight for energy and CO_2 and water**
4. **Any organism is able to be classified according to how it gets its energy**
5. **A food web will be affected by any increase or decrease of a species population**
6. **Climate change and ocean acidification may be affecting some species and therefore the Antarctic food web, and the distribution of some species, will be affected.**

Key words

Food chain, food web, producer, herbivore, carnivore, omnivore, consumer, decomposer, predator. Krill, phytoplankton, zooplankton, baleen whale, toothed whale

The Antarctic Food Web

Food chains make up the more complex food webs that describe the feeding patterns of any ecosystem. A food chain must start with a **producer** because these organisms are the group that makes their own food. A producer uses photosynthesis to convert the sun's energy into food. A producer is usually a green plant, anything from microscopic algae, (as in phytoplankton), to a tree. The raw materials are sunlight for energy, with carbon dioxide and water providing the raw materials for growth. Producers drive all food chains and food webs. The next animal in the chain are **herbivores** that eats the producer. **Carnivores** are next in the chain. These are animals that eat herbivores. **Omnivores** eat herbivores and producers. The "top carnivore" or "top predator" is the last animal in the food chain. This animal eats others but is not eaten by any other organism. The arrow in a food chain always points in the direction of the flow of energy and can be translated as "is eaten by". At each step only 10% or less energy is passed along the chain.

Decomposers This group of animals break down dead plants and animals as a food source releasing nutrients back into the food chain. Bacteria are an example of decomposers in the Antarctic marine system. In the Antarctic the food chain is very efficient as there are not very many organisms in each chain.

<u>Example of an Antarctic food chain</u>

Phytoplankton → **Krill** → **Whale**

Producer → **Herbivore** → **Carnivore**

Plankton are the basis of the Antarctic food chain. They are marine and freshwater organisms that, because they are non-motile or too small or weak to swim against the current, exist in a drifting state in the water they live in. The plantlike community of plankton is called **phytoplankton**, and the animal-like community is known as **zooplankton.**

Phytoplankton are tiny plants that capture the energy of the sun and turn it into food, these are the producers of the Antarctic food web. As they are so tiny, they can divide and grow very quickly when the more intense and longer lasting light of summer arrives.

Krill

Krill are small crustaceans that are found in all the world's oceans. It is a herbivore that feeds on phytoplankton and zooplankton. It uses a "basket" made from its front legs to filter out the plankton from the water. The name krill comes from the Norwegian word krill meaning "small fry of fish". Krill are considered an important part of the Antarctic food web. They are near the bottom of the food chain because they feed on phytoplankton converting these plants into a form suitable for many larger animals for whom krill makes up a large part of their diet. In the Southern Ocean the Antarctic krill make up an estimated biomass of around 379,000,000 tons, more than that of humans. Of this, more than half is eaten by whales, seals, penguins, squid and fish each year.

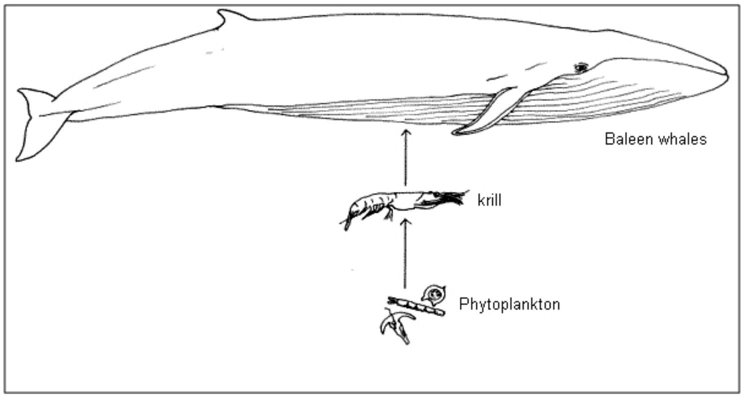
Whales

Whales are the largest animals to have ever lived, larger even than the dinosaurs. There are two reasons why they have managed to attain such enormous size; well over 100 tons for the largest blue whales and nearing this amount for some other whale species.

1. **Whales live in the ocean** and so the buoyancy of the water can support their great bulk rather than having to be propped up and moved on land by legs and muscles. Like most other animals, the density of a whale is very close to that of water.

2. **Whales tap the food chain low down** close to the producers so there are few steps and so little energy is lost meaning more is available to the whales, so they are able to grow to enormous sizes.
   The alternative consequence of this is that the higher up a food chain you get, the lower the biomass of animals (that is the number of animals multiplied by their weight) because there are more steps and so more energy is lost.

   A simple Antarctic food chain is the secret to the success of the baleen whales – keep the chain short and transfer as much energy as possible as efficiently as possible.



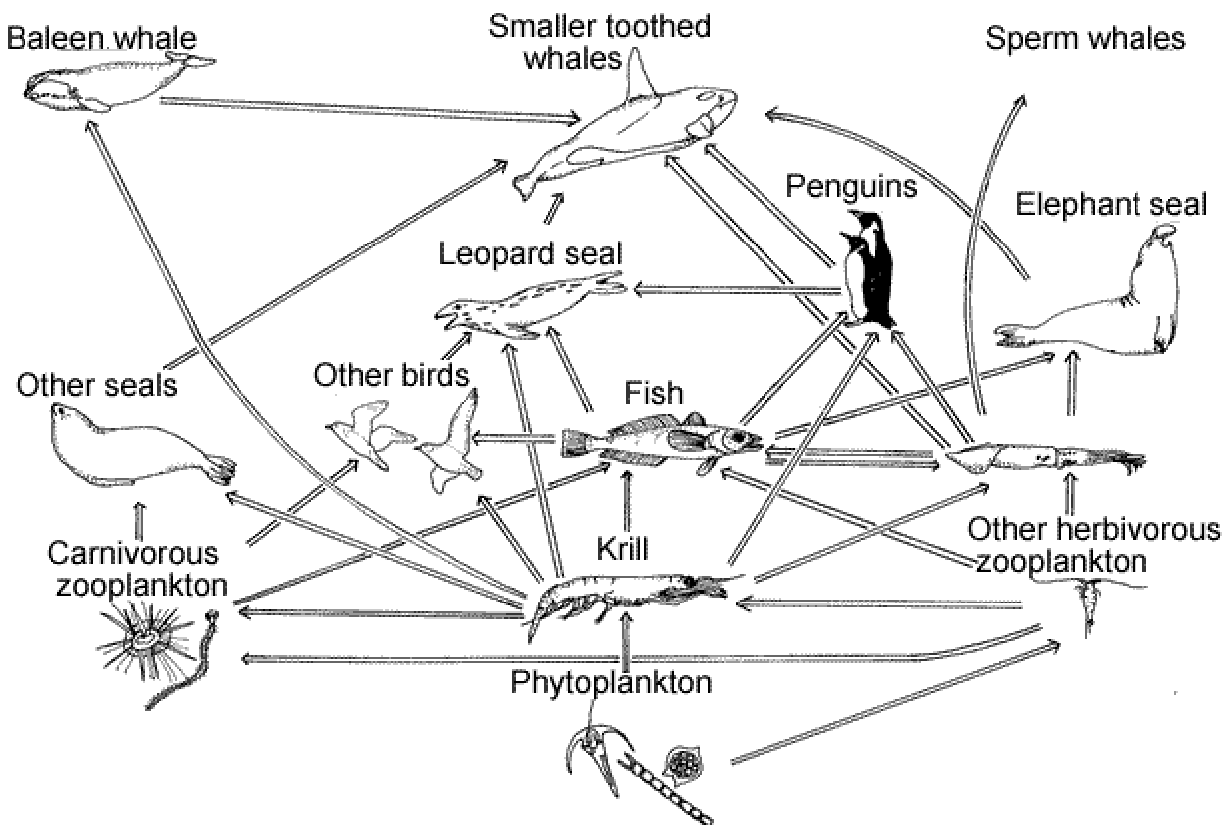
Food web

A food web shows the complex interactions of the plants and animals in an ecosystem or habitat, showing what is eaten by what. This is a more accurate picture of the ecosystem than the food chain.

Antarctic food web

The Antarctic food web is relatively simple compared to ecosystems in other parts of the world. There are fewer different species, but greater numbers of them. For example, the second most numerous mammal in the world, (after man), is the crab-eater seal.

A key part of the Antarctic food web are krill, small shrimp-like crustaceans that the great majority of Antarctic animals, seals, whales, penguins and other birds and fish feed on.



Questions / think, pair, share / discuss

1. Why must a producer start a food chain?
2. What will happen to the food web if one plant or animal becomes more or less abundant?
3. How has the Antarctic food web been affected in the past? (Whaling and sealing) Which organisms would have become more abundant? What else do you think might have happened?
4. Are any animals in the food web threatened now? Will this have any effect on any other organisms?

Activities

1. Draw a New Zealand food chain labelling the producer, herbivore and carnivore.
2. Draw as many Antarctic food chains as you can from the food web illustration.
3. Make a food chain bookmark.
4. Using cut out illustrations of the organisms in the Antarctic food web, reconstruct the feeding patterns.
5. Study of one animal in the Antarctic food web. What does it feed on? What feeds on it?
6. Whale study. Investigate the difference between baleen and toothed whales.
7. Seal study. Investigate the difference between crab-eater seals and leopard seals.

Practical work

An Antarctic food chain dish

Ingredients

White rice
Green food colouring
Red food colouring
Whole shell on prawns
Small squid

Method

Cook the rice by the absorption method. Half a cup of rice for three times volume (one and a half cups) of water.
Add green food colouring at the start of cooking. Wash the starch off once its cooked.
Cook about a third as much of this rice and add red food colouring
Cook the squid and prawns by frying in a little oil. Remove and pat dry, removing excess oil with a paper towel.

Assemble

On a suitable plate; blue or aluminium foil
Green rice are phytoplankton, spread around
Sprinkle the red rice, zooplankton, on top
Prawns are krill on top of the rice
Squid is squid
You could add white rice and sweet chili sauce
The top predator is you

The Antarctic Food Web Level 5

Main ideas;
A food web will be affected by any increase or decrease of a species population
Climate change and ocean acidification may be affecting the Antarctic food web, by increasing or decreasing the abundance of some species, while affecting the distribution of some other species.

Key words
Food web, abundance, climate change, sustainable fishing, sea-ice

The Antarctic Food Web

Plankton form the basis for the Antarctic food web. These are marine and freshwater organisms that, because they are non-motile or too small or weak to swim against the current, exist in a drifting state in the water they live in. The term *plankton* is a collective name for all such organisms—including certain algae, bacteria, crustaceans, molluscs and colenterates as well as representatives from almost every other phylum of animal. The plantlike community of plankton is called **phytoplankton**, and the animal-like community is known as **zooplankton.** The chief components of marine phytoplankton are found within the algal groups and include diatoms and diaflagellates and coccolithophorids. In the oceans, phytoplankton biomass rises and falls according to multiyear cycles and appears to be sensitive to changes in sea surface temperatures, climate change, and ocean acidification.

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Of this, more than half is eaten by whales, seals, penguins, squid and fish each year.

Humpback whales lunge feeding on krill

Photo; Wikipedia

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The second most numerous mammal in the world (after man) is the crab-eater seal.
A key part of the Antarctic food web are krill, small shrimp-like crustaceans that the great majority of Antarctic animals, seals, whales, penguins and other birds and fish feed on.

Producers; Phytoplankton, which may be carried by sea currents

Sea ice algae, which live on the underside of sea ice but may fall to the sea floor.

Macroalgae, leafy seaweeds and algae that are attached to rocks and corals on the sea floor

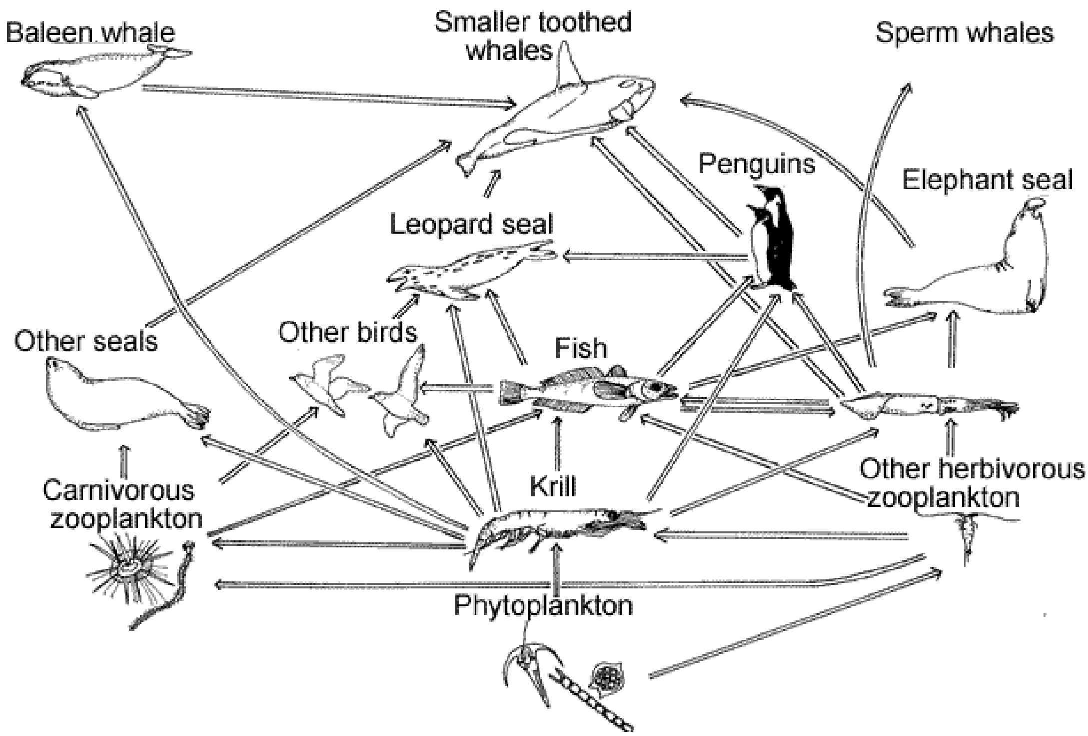
Microalgae, microscopic algae that lives on the surface of sea floor sediments

Consumers;

1. Herbivores; Krill, Herbivorous zooplankton
2. Carnivores; Carnivorous zooplankton, Squid, Fish, Birds, Seals (Elephant, Leopard and others), Penguins

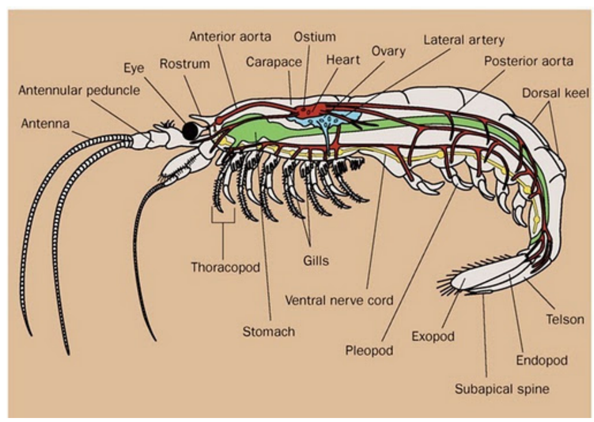
Top predators; Baleen whale, Sperm Whale, Smaller toothed whales

Decomposers; Bacteria

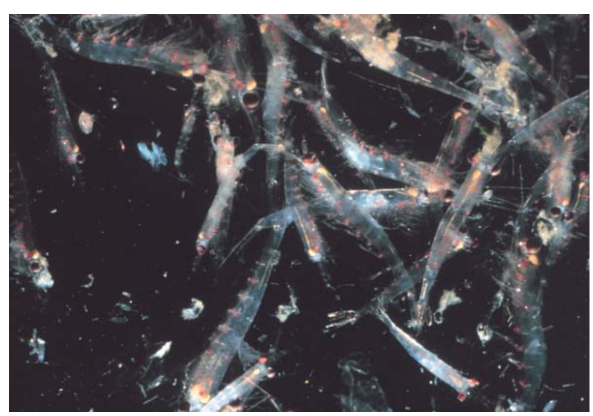


Further Krill Facts

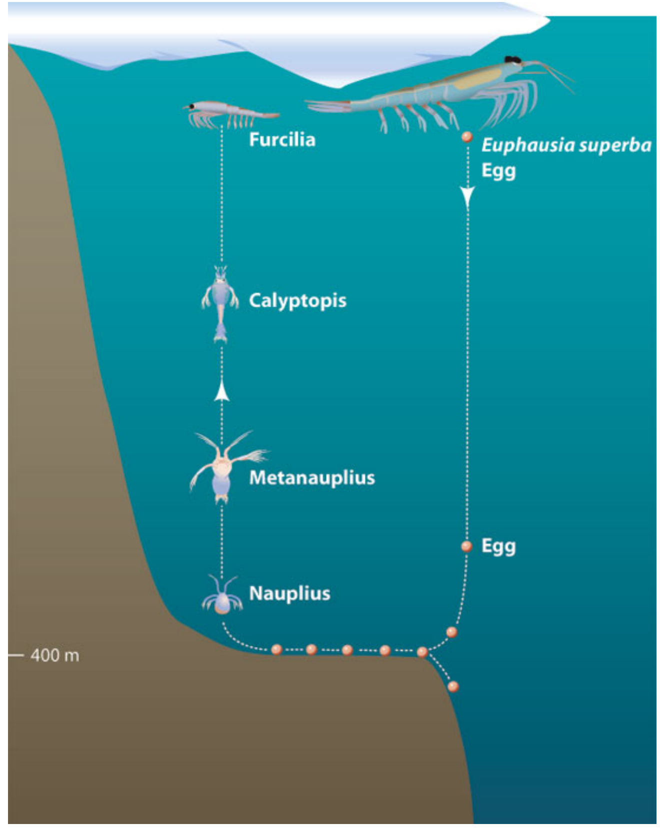
Krill often are referred to as “keystone” species because they play such an important role for many marine systems.



Some species of krill are bioluminescent. This means that Antarctic krill emit a yellow-green light that is thought to either camouflage the krill's shadow or aid the krill in mating or schooling at night. Krill are invertebrates that grow to about two inches in length and live in large schools, or swarms, as dense as 10,000 krill per cubic meter of water.



Krill Life Cycle



Currently, 85 species of krill have been identified in different oceans around the world. They live in habitats ranging from abyssal depths (5,000 m) to near shore kelp beds (10 m), and from warm tropical seas to the freezing Antarctic Ocean.

Krill start life as eggs that sink and hatch in spring. They develop through larval stages as they swim back to the surface, reaching the fourth (furcilia) stage by winter. Krill that hatch at the depth of the Antarctic shelf (300-400 metres) can swim back to surface waters before winter and find phytoplankton to eat before they use up their stored supplies. Furcilia that make it survive their first winter by feeding on algae and zooplankton on the under surface of pack ice.

Illustration by Jayne Doucette, WHOI Graphic Services

Formation Behaviour

Krill typically are found in concentrated aggregations. Usually, one to ten individuals occupy a cubic meter of ocean. However, denser patches called shoals have concentrations of 10 to 100 krill per cubic meter, and swarms have 1000 to 100,000 krill per cubic meter. This schooling behaviour is an effective defence mechanism. It confuses smaller visual predators that prefer to isolate and take single individuals.

Swarms can extend 10 m or more in diameter and often elicit a frenzied feeding response from whales and other predators like fish and birds. This is particularly true when these aggregations are in the upper water column, and escape routes are restricted by the ocean's surface.

Where krill can be found in Antarctica

Antarctic krill live in the surface waters of the Southern Ocean, which extends north from the Antarctic continent to the polar front -- an area where the cold water of the Antarctic submerges beneath the warmer waters of the Atlantic, Indian, and Pacific Oceans. As this deep, cold water rises to the surface of the Southern Ocean, it brings nutrients from all the world's oceans into the sunlight, making this area home to what is possibly the earth's largest assemblage of phytoplankton. It is this massive gathering of phytoplankton that allows for such tremendous swarms of krill, which harvest the miniscule phytoplankton particles with a specially developed feeding basket that filters them out of the water. The krill also find nourishment by scraping ice algae off the underside of pack ice, particularly in spring. These are successful techniques, apparently, since the total biomass, or weight, of Antarctic krill -- which is estimated to be between 100 and 800 million tons -- may be the largest of any multi-cellular animal on the planet.

Climate Change

In the early life stages krill require deep water with low acidity and a narrow range of temperatures for their eggs to successfully hatch and develop. The larvae then feed on algae on the underside of sea ice. The adults require suitable temperatures and enough of the right type of food (larger phytoplankton) to successfully grow and reproduce. Many of these critical environmental features (temperature, acidity, sea-ice and food availability) could be affected by climate change.
Penguins are being affected by the warming of our planet. Different species of penguins have different ways of nesting and breeding and the warming of Antarctica is affecting different species in different ways. These effects are also variable across Antarctica as some parts of Antarctica warm while other areas have not warmed so quickly. For example; warming temperatures are creating changes that benefit Adélie Penguins. In southern portions of the Antarctic coast, areas of once impenetrable pack ice have loosened allowing easier access by penguins. Penguins would much rather swim in the ocean than walk on sea ice that covers it. Further north, however, along the warmer Antarctic Peninsula, sea ice habitat that Adélies depend on is disappearing. These penguins exist only where there is sea ice for at least a portion of the year.

Questions/ think pair share/ discuss

1. What could be the consequences for harvesting any part of the Antarctic food web?
2. What does the term “sustainable fishing” mean?
2. Should people fish in the Southern ocean?
3. What do you know about the effects of global warming on Antarctica? Could the warming of the oceans affect the food web?

http://phys.org/news/2013-08-antarctic-seas-impact-krill-habitats.html#jCp

Activities

Watch https://www.youtube.com/watch?v=1_BqC9IIuKU to see whales feeding on krill.

Suggested areas of research topics

1. Krill is a resource that is harvested in the Southern Ocean. List all the organisms that would be affected by a decrease in krill numbers.
   https://www.ccamlr.org/en/fisheries/krill-fisheries-and-sustainability
2. Managed fishing of the Antarctic toothfish (*Dissostichus mawsoni*) already occurs. Find out about the Antarctic toothfish industry. Who is involved and why? How is it this fishing industry managed?

https://www.niwa.co.nz/fisheries/research-projects/the-ross-sea-trophic-model/toothfish-fishery

3. Examine the effect of the recent warming of the Antarctic Peninsula on the Adelie and Emperor penguin. How will other penguin species be affected? Identify which penguin species will possibly; relocate, adapt, decline in numbers.
   Give reasons.

http://www.penguinscience.com/classroom_home.php
http://www.penguinscience.com/clim_change_ms.php

4. Leopard seal and crabeater seals both live on the sea-ice. Do they compete for food? Look carefully at the teeth of each one. The leopard seal is on the left and the skull of the crabeater seal is on the right. What is their relationship within the food web?
   http://www.anta.canterbury.ac.nz/resources/pengui.html

photo;Wikipedia

5. Research why the Antarctic Peninsula is warming more quickly than the Antarctic continent. How could this affect the wildlife of Antarctica? Hint; some species can move to the warming areas, while those species adapted to very cold conditions may not have anywhere to migrate to. How has the temperature affected the sea-ice? What are the implications for wildlife?

6. Marine Protected Areas are proposed for areas of the Southern Ocean, the ocean south of 60˚ latitude.
   Find out more at this website ;
   https://www.ccamlr.org/en/science/marine-protected-areas-mpas

Exploring the Extreme Environment of Antarctica Level 3 & 4

A History of Exploration and Achievement

Surviving in the extreme conditions of Antarctica is a challenge. Cold and windy conditions are immediately apparent south of the 60˚ latitude line, when the sea and air become very much colder. The first ships that sailed into these waters encountered rough seas, large waves and ice-bergs. When Captain Cook sailed into Antarctic waters in 1773 and found rocks embedded in icebergs, so he guessed there was a land mass further south. Last century, in the early 1990's, people began to venture into the interior of Antarctica in the interests of exploration, science and the mapping of this new continent. Some of the early expeditions are listed in the table below.

Expedition leader	**Achievement**	**Challenge**
Carsten Borchgrevink Great Britain 1899	Landed at Cape Adare and built huts. First confirmed landing on the Antarctic continent. Spent the first winter in Antarctica.	They chose one of the most inhospitable places in Antarctica to build a hut. It was very windy and cold.
Captain Scott United Kingdom 1901	The first Antarctic expedition to try to reach the South Pole. They reached 82˚ south before turning back.	Snow blindness, scurvy.
Ernest Shackleton United Kingdom 1907	The expedition came to within 156km of the South Pole	Food supplies ran out.
Douglas Mawson Australian 1909	Reached the South Magnetic Pole	Food needed to be rationed. Low -24˚C temperature. Man hauling sledges through unknown terrain.
Roald Amundsen Norwegian December 1911	Reached the South Pole for the first time. Amundsen used skis and sled dogs, both of which he was familiar with.	Amundsen was the first to travel this route, but he was able to travel quickly and efficiently in the harsh environment.
Captain Robert Scott Britain January 1912	Reached the South Pole 35 days after Amundsen.	Cold, exhaustion and lack of food. All of the five man team perished on the return journey, only 18km from a supply depot.
Douglas Mawson Australian 1912	Trekked across George V land back to base in Commonwealth Bay. A new section of coast was discovered. Radio was used for the first time in Antarctica	Mawson's two companions died; Belgrave Ninnis fell into a crevasse and Xavier Mertz suffered frostbite and died after eating husky dog liver. Mawson was alone for

Shelter in the Snow

The early explorers built kitset huts with timber carried on the ships they sailed to Antarctica in. These huts were often cold and uncomfortable to live in.

Some huts were insulated with seaweed or paper mache against the cold temperatures and wind. Carsten Borchgrevink's hut at Cape Adare is pictured *Photo; Wikipedia*

Tents were used to in the early 1900's to sleep in, and for shelter, when groups went out on sledging expeditions into the interior of the continent. The same design is still used today by scientists and explorers in Antarctica. The triangle shape withstands high winds. Polar tents have a flap around the outside so that snow can be piled onto it to secure the tent.

Photos; Wikipedia

Research Stations

Different countries have built research stations for their scientists to work from. There are a variety of designs that are all constructed with the harsh climate of Antarctica in mind. The Amundsen-Scott Station at the South Pole *(right)* was built by the United States of America. Some of the stations are supported on piles that allows snow to blow under the building, rather than accumulating against the building. The research bases are all securely fixed into the rock or ice, depending on the surface and where they are built. Some stations are able to be moved in case of changes in the ice they are anchored onto. Most of the permanent bases have people living in them all year around, with lower numbers of people during winter. Summer is a busy time for scientists as the sunlight hours are long and the weather is a little warmer. The research stations are well-heated and insulated compared to the timber huts of the heroic era explorers.

Clothing

Early Antarctic explorers wore heavy layers of woolen fabric that absorbed the moisture produced by sweat or condensation. At night this moisture froze, which meant that in the morning clothes that had to be put on were stiff and cold with ice. Scientists and explorers today are able to wear lighter and more efficient fabrics. These materials are lighter and easier to wear. They keep out the cold and wind and keep the wearer warm and dry.

Extreme Cold

The extreme cold of Antarctica means that people need to be alert to the dangers of the environment. Early explorers suffered from frostbite and hypothermia in the cold conditions. When a wind is blowing, a wind chill factor is added to the day's temperature, lowering the actual temperature. Frostbite is when parts of the body; usually the fingers, toes and face, become so cold the tissue starts to freeze. Hypothermia is a general chilling of the body, leading to a fall in the internal body temperature. The chart below shows the effect of wind on an already cold environment which will in turn affect anything living.

	Air Temperature (Celsius)																
Wind Speed (km/hr)	0	-1	-2	-3	-4	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60
6	-2	-3	-4	-5	-7	-8	-14	-19	-25	-31	-37	-42	-48	-54	-60	-65	-71
8	-3	-4	-5	-6	-7	-9	-14	-20	-26	-32	-38	-44	-50	-56	-61	-67	-73
10	-3	-5	-6	-7	-8	-9	-15	-21	-27	-33	-39	-45	-51	-57	-63	-69	-75
15	-4	-6	-7	-8	-9	-11	-17	-23	-29	-35	-41	-48	-54	-60	-66	-72	-78
20	-5	-7	-8	-9	-10	-12	-18	-24	-30	-37	-43	-49	-56	-62	-68	-75	-81
25	-6	-7	-8	-10	-11	-12	-19	-25	-32	-38	-44	-51	-57	-64	-70	-77	-83
30	-6	-8	-9	-10	-12	-13	-20	-26	-33	-39	-46	-52	-59	-65	-72	-78	-85
35	-7	-8	-10	-11	-12	-14	-20	-27	-33	-40	-47	-53	-60	-66	-73	-80	-86
40	-7	-9	-10	-11	-13	-14	-21	-27	-34	-41	-48	-54	-61	-68	-74	-81	-88
45	-8	-9	-10	-12	-13	-15	-21	-28	-35	-42	-48	-55	-62	-69	-75	-82	-89
50	-8	-10	-11	-12	-14	-15	-22	-29	-35	-42	-49	-56	-63	-69	-76	-83	-90
55	-8	-10	-11	-13	-14	-15	-22	-29	-36	-43	-50	-57	-63	-70	-77	-84	-91
60	-9	-10	-12	-13	-14	-16	-23	-30	-36	-43	-50	-57	-64	-71	-78	-85	-92
65	-9	-10	-12	-13	-15	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
70	-9	-11	-12	-14	-15	-16	-23	-30	-37	-44	-51	-58	-65	-72	-80	-87	-94
75	-10	-11	-12	-14	-15	-17	-24	-31	-38	-45	-52	-59	-66	-73	-80	-87	-94
80	-10	-11	-13	-14	-15	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
85	-10	-11	-13	-14	-16	-17	-24	-31	-39	-46	-53	-60	-67	-74	-81	-89	-96
90	-10	-12	-13	-15	-16	-17	-25	-32	-39	-46	-53	-61	-68	-75	-82	-89	-96
95	-10	-12	-13	-15	-16	-18	-25	-32	-39	-47	-54	-61	-68	-75	-83	-90	-97
100	-11	-12	-14	-15	-16	-18	-25	-32	-40	-47	-54	-61	-69	-76	-83	-90	-98
105	-11	-12	-14	-15	-17	-18	-25	-33	-40	-47	-55	-62	-69	-76	-84	-91	-98
110	-11	-12	-14	-15	-17	-18	-26	-33	-40	-48	-55	-62	-70	-77	-84	-91	-99
	0 to -10 Low			-10 to -25 Moderate			-25 to - 45 Cold			-45 to -59 Extreme			-60 Plus very Extreme				

Snow blindness was common among explorers. Today sunglasses and ski goggles are worn to prevent this. Dehydration is also a danger as Antarctica is a dry climate and the available water is often in snow or ice form. Drinking 4 litres of water a day is advised to stay healthy.

Questions/ think pair share / discuss

1. What do animals, plants or bacteria need to live?
2. How do people survive in Antarctica? In what way is this different from animals who live in extreme environments?
3. What is hypothermia?
4. What is the wind chill factor? What could you do to prevent hypothermia or frostbite?
5. The research stations are mainly around the edge of the Antarctic continent. Why do you think this is? What does this mean for the scientists?

Activities

1. This website has an online wind chill calculator. Use it to calculate some wind chill factors. http://www.srh.noaa.gov/epz/?n=wxcalc_windchill
2. Design your Antarctic research station. Remember you are building in the coldest, windiest and driest place in the world. The early explorers sometimes suffered from scurvy; a lack of Vitamin C found in fruit and vegetables. How could you counter this possibility?
3. Make a list of your Antarctic clothing. These websites might help.

http://www.rte.ie/tv/tomcrean/assets/kids-corner-clothing.pdf
http://www.coolantarctica.com/Antarctica%20fact%20file/science/clothing_in_antarctica.php
http://discoveringantarctica.org.uk/science-and-exploration/living-in-antarctica-today/what-not-to-wear/

4. Why is the station "on legs"?

Photo; Paul Knight

The British Halley VI research station; described as "dismantable." Why is this a good description, and a good idea?

Practical Work

The surface of your skin will naturally lose the heat of your body. If a wind is blowing over your skin the heat loss is increased.

Try this:

1. Hold your hand in front of a moving current of air; a fan, or outside if it is windy (and cool). The faster the wind, the more rapidly your skin will cool as the warm layer of air is moved away from your body.
2. Wet your hand and then place in front of the moving air.
3. Use an ice cube to cool the skin on the back of your hand, then hold your hand in front of the moving air. Does it feel warmer or cooler?

Life in the Extreme Environment of Antarctica Level 5

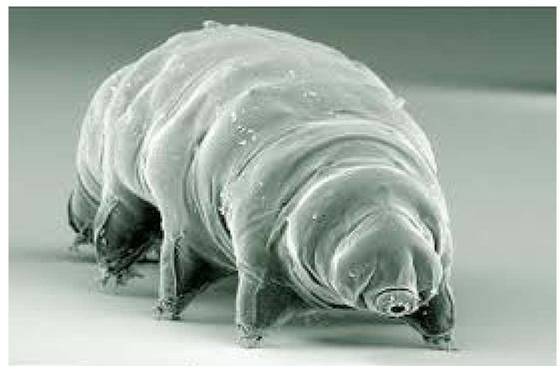
Dry Valley Life

Explorer Robert Scott, who discovered the Dry Valleys in 1903, looked over one of them and called it "a valley of death." This was, of course, before scientists arrived. Today, we know that Scott was wrong.

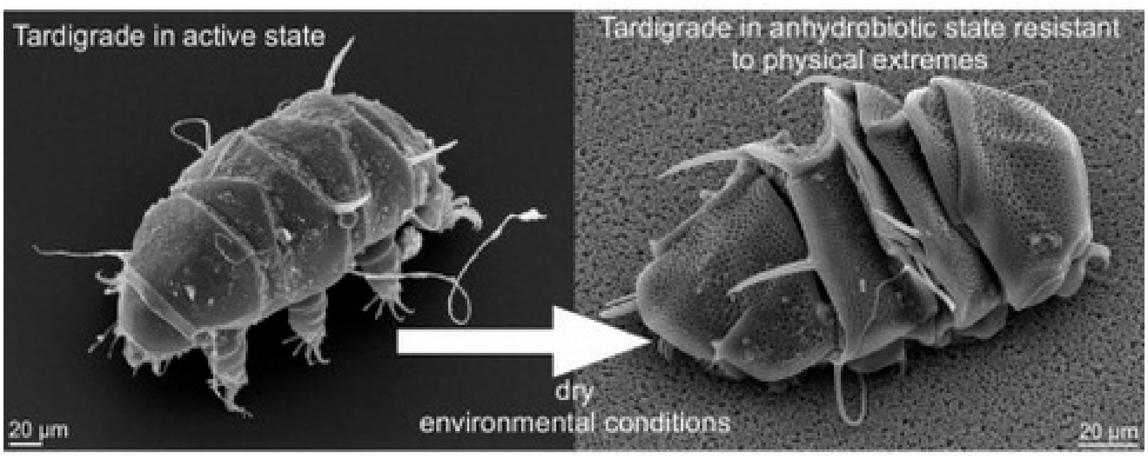
Researchers have discovered that the Dry Valleys are home to a variety of extremophiles (organisms that live in extreme environments). Among them are lichen and mosses, communities of microbes (including cyanobacteria), and nematodes (microscopic worms). Researchers continue to find and study these and other organisms and their adaptations, which allow them to survive in one of the most punishing environments on the planet. Some of these animal and plants have evolved ways to survive the extreme cold and lack of water.

Solutions to survival by invertebrates

1. Dehydration This can be partial or "complete" (also called anhydrobiosis)
Anhydrobiosis removes enough water that the animal will not freeze. It is obviously inactive, but is effectively "instant life" when water is added. **Tardigrades** (water bears) are able to do this. They are perhaps the toughest animal on the planet



Mudfooted.com



www.quora.com

2. Freezing
Many New Zealand insects do this for example the **Alpine weta** and the **Alpine cockroach** freeze readily at around -30˚C. The ability to freeze is associated with a reduction in body water content.
Pictured left; New Zealand Tree Weta

3. Super cooling

The Antarctic's largest animal, the **springtail**, is only just visible to the naked eye and can supercool. The springtail can slow down their metabolism to save energy. In winter it is as low as –38˚C. This insect like creature uses sugars as colligative antifreezes, in the form of a sugar called glycerol, which lower their freezing point. They live under rocks feeding on fungus and bacteria and have been found as far south as 86˚ latitude in Antarctica.

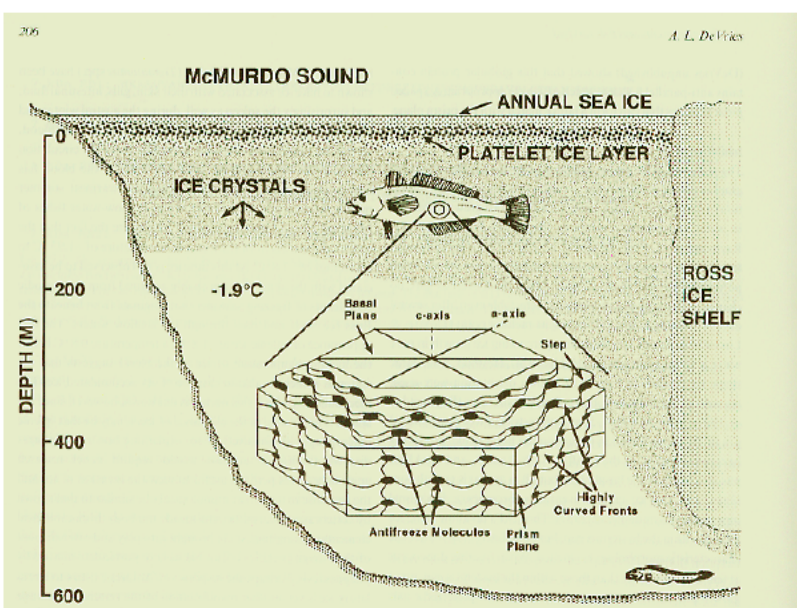
Photo;Wikipedia

Tiny **nematode worms** are also able to cope with the extreme cold by lowering their freezing point. They are able to protect themselves from the crystals that develop as water freezes inside their cells by producing proteins that pack around the sharp-edged crystals. Nematodes are able to dehydrate when conditions get too dry. The worms blow around in the wind and when moisture is available; perhaps when melt from glaciers provides freshwater streams they revive. No one is sure how long nematodes can survive this state, but these worms have rehydrated into a living worm after 60 years in a freeze-dried mode.

Credit: Byron Adams

Fish in the freezer

Sea water is colder than fresh water and freezes at a lower temperature of -1.9˚C, rather than at 0˚C, because of the salinity of the sea. So that their blood and tissues do not freeze at this lower temperature polar fish in the Arctic and in the Antarctic have developed an anti-freeze. Fish in both areas have evolved this adaptation separately. Arctic fish have added a protein and Antarctic fish, a sugar plus a protein. This anti-freeze prevents ice crystals forming and interrupts the freezing process that would freeze their blood and tissues.



Seals and Penguins

Seal and penguins are both endotherms; warm blooded vertebrates.
Right; King penguins walk amongst Elephant seals

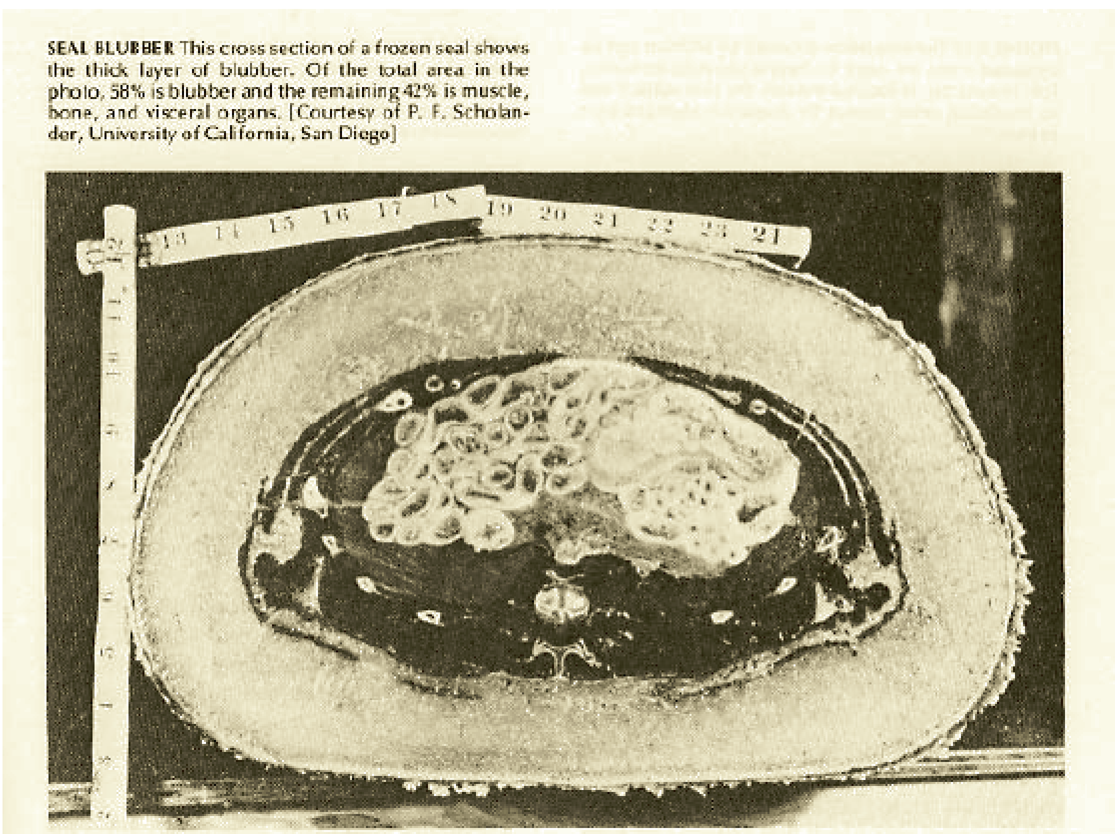
Size and surface area

Warm blooded animals in cold climates are pretty large, even the smallest Antarctic birds are on the large side and the smallest Antarctic penguin, the Rockhopper is a fairly hefty 2.5kg. The Adelie and Emperor penguins of the deep-south are larger still. Adult weights are 5kg (for the Adelie and 30kg for the Emperor and King; a similar size to an overweight 10 year old child, but with a man-sized chest measurement. The larger the animal, the smaller the surface-area: volume ratio and so the less relative area there is to lose heat.

Photo; Image.posterlounge

Seals

Seals have **fur** which is a good insulator on land, and **blubber** which is a good insulator in the water. The illustration below shows a seal with a thick layer of blubber. Of the total area 58% is blubber and 42% is muscle, bone and visceral organs.



Penguins

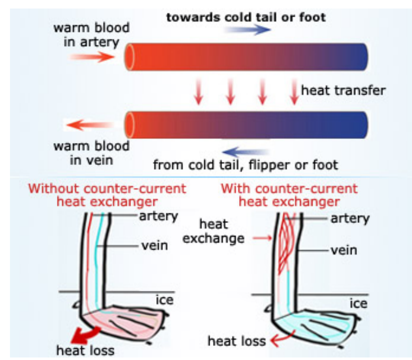
Penguin feathers

Penguin feathers keep penguins warm on land. Penguin feathers aren't the large flat feathers that flying birds have, they are short with an under-layer of fine woolly down. Penguin feathers are also very good at shedding water when the bird emerges from the sea. They overlap and give a good streamlined effect in the water and have excellent wind-shedding abilities when on the land. When it gets very cold, penguins can puff their feathers out to trap more air for even better insulation. When it gets too hot, they fluff their feathers out even more so that the trapped warm air can escape and enable the penguin to cool down. Penguins have the highest density of feathers per unit of surface area than any birds.

Under the skin, a layer of fat

External fur and feathers are the most efficient insulators on a weight for weight basis, but can be ruffled by wind and are much less useful when wet. In the water penguins have a sub-cutaneous layer of fat to keep them warm. This fat layer also serves as a valuable energy store. This fat layer keeps all warm blooded cold water animals operational down to minus 1.9°C. Sea water freezes at this temperature and so cannot be colder than this without being solid. A penguin can have up to 30% of its body weight as blubber (fat).

Penguins have two areas where their body is very poorly insulated and where they can lose a lot of heat, these are flippers and their feet.



their

These regions give penguins at the same time a problem and solution. A problem because of the heat loss, and a solution because they can be used for cooling down. Its good being brilliantly insulated when it's very cold, but when you use a of energy and so generate heat, or the temperature rises, being able to lose that heat is a problem.

a

lot

not

www.reddit.com

The solution is that the muscles that operate feet and flippers are not located in the feet and flippers, but deeper in the warmer regions of the penguin's body. The feet and flippers are moved by tendons that pass through them and attach to the bones of the toes, ankle, and wrist. This means that if the feet and flippers get really cold as they can still be operated normally by muscles in regions that are at normal body temperature and so are still fully functional. Penguins have a heat-exchange blood-flow to these regions. The warm blood entering the feet flows past cold blood leaving so warming it up in the process and cooling the blood entering at the same time, the same sort of thing happens in the flippers. Blood in the feet and flippers is kept significantly colder than in the rest of the body much of the time. By the time the blood re-enters the rest of the body it has been warmed up and so does not cool the core body temperature.

Questions / think pair share / discuss

1. Why do you think Scott and the early explorers missed seeing life in the Dry Valleys?
2. Do you think there are any similarities to life in the extreme environment of Antarctica and the possibility of life on Mars?
3. Make a "T" diagram comparing early explorers clothes and shelter with modern scientists and

explorers.

4. Explain to your friend how fish manage to survive in waters colder than 0˚C.

Activities

1. Watch these You tube clips to see tardigrades in action

https://www.youtube.com/watch?v=ZuxwisK-8f8
https://www.youtube.com/watch?v=u2lkPq3Cil0

2. Research one of the animals that survives the cold in Antarctica. Present your findings to the class by a poster or slide show presentation.
3. Check out these websites for further information

http://www.livescience.com/30991-weird-wildlife-real-animals-antarctica-penguins.html
http://www.coolantarctica.com/Antarctica%20fact%20file/science/cold_penguins.php

Practical work

1. Look for water bears in mosses and lichens. Rehydrate and then use a microscope.
2. Plan an investigation to discover the effect on the freezing temperature of water if salt or sugar is added to make a solution. What is the salinity of sea water? Pure water freezes at 0˚C and sea water at – 1.9˚C.
3. Calculate the surface area to volume ratio of a 1cm cube and a 3cm cube

1cm cube Volume = 1 x 1 x 1 = 1cm^3
Surface Area (6 faces) = 6 x (1 x 1) = 6cm^2
For 1cm^3 of volume there are 6cm^2 of surface area to lose heat from; 6 / 1 = 6cm^2 per 1cm^3

Surface-area : volume ratio is 6:1

3cm cube Volume = 3 x 3 x 3 = 27cm^3
Surface Area (6 faces) = 6 x (3 x 3) = 54cm^2
For 27cm^3 of volume there are 54cm^2 of surface area to lose heat from; 54 / 27 = 2cm^2 per 1cm^3

Surface-area : volume ratio is 2:1

If you imagine these are simple cubic warm-blooded animals, the small cube has 3 times the surface area per unit of volume compared to the large cube.

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